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# **Economic Migration and Business Cycles in a Small Open Economy with Matching Frictions**

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# Economic Migration and Business Cycles in a Small Open Economy with Matching Frictions

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## Abstract

With the free movement of labour in Europe, economic migration has become an important determinant of labour supply. Cyclical migration exceeds one percent of the population in many countries and affects (un)employment and wage setting. The main contribution of this paper is that it models migration as an endogenous decision in a search-and-matching framework, where labour market institutions play an important role. It shows that, contrary to typical beliefs, migration can amplify business cycles. After a positive shock to the economy, immigration increases the labour force and initially unemployment. The latter reduces a worker's outside option in wage negotiations, resulting in a lower wage increase than when there is no migration. With cheaper labour firms post more job vacancies, which increases the probability that unemployed workers find jobs and attracts new workers to immigrate. Attenuated response of wages and the stronger response of employment to shocks result in a flatter Phillips curve. ...

*JEL classification:* E23, E32, J21, J61, J64.

*Keywords:* Migration; Search and Matching; Unemployment; Labour force; Business cycles.

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## Non-technical summary

With the creation of the European common market and its principles of the free movement of goods, services, capital, and labour, migration within the European Union has become easier. Moreover, migration has typically been viewed as a welcome phenomenon, especially in the context of a monetary union, because labour mobility can help to alleviate the effects of region-specific shocks. This can be especially important in small open economies, where migration can be an important determinant of the labour supply at cyclical frequencies.

This paper models migration in a small open economy, where people can decide whether to search for work in the home economy or abroad. When deciding whether to migrate or not, people compare their wages, employment prospects, and unemployment benefits at home and abroad. This means that the migration decision is endogenous and any shock that causes a change in any of these variables between home and foreign economies will lead to migration flows. To show how the model works in a realistic setting, the model is calibrated to Ireland, which experienced significant migration flows throughout its history.

The main finding of the paper is that migration can actually amplify cyclical fluctuations due to country-specific shocks. The reason for amplification is that after a positive shock to the home economy, labour force increases due to immigration, which causes wages to increase by less than without immigration. Because wages increase by less, firms become more profitable and post more job vacancies, which in turn attracts new workers to the economy. Because there are simultaneously more job vacancies and more searching workers, matching of firms and workers is faster, and employment and output increase more quickly and by more. An interesting side effect is that because wages do not react a lot to a shock and employment increases faster, the result is a flatter Phillips curve, especially when migration flows are large.

When there is an increase in immigration that is not related to home economic conditions, then this leads to a temporary increase in unemployment. This increase is short-lived if wages can adjust quickly, so that firms post more vacancies and unemployed can find work. Moreover, additional net government spending associated with unemployment benefits for newcomers is quickly reversed due to higher tax collections. When wages do not adjust to immigration, unemployment persists and net government spending on unemployment benefits is not offset by the increase in tax revenues.

The paper also shows that the impact of migration on the home labour market depends both on the relative size of the home economy and its openness to migration. When an economy is small and open to migration towards a large region, the size of its labour market is small relative to size of the pool of potential migrants. This is because a small emigration from the perspective of a large country, for instance a fraction of the percentage point of population, means a large immigration from the perspective of a small country, whose population is small compared to the large country. In such cases, migration significantly affects labour supply in the home country and also the wage setting process. If this is the case, then country-specific shocks can be significantly amplified by migration.

# 1 Introduction

Countries in the European Union have opened their labour markets for migration within the union, in line with the principles of free movement of goods, services, capital and labour. Migration in a monetary union is typically viewed as a welcome phenomenon, because labour mobility can alleviate region-specific shocks, as emphasised by Mundell (1961). Despite the formal opening of European countries to within-union migration, the actual degree of migration has been low and mostly driven by unemployment differentials rather than wage differences. However, during the recent crisis, migration has increased markedly in Europe (Huart and Tchakpalla, 2015).

There are broadly two approaches to modelling migration in dynamic stochastic general equilibrium (DSGE) models. The first approach is based on a setup where labour markets are frictionless, and either real (Mandelman and Zlate, 2012) or nominal (Chortareas et al. (2008) and Farhi and Werning (2014)). The second approach is based on a setup that explicitly takes into account search and matching frictions on the labour market. An important advantage of models based on search and matching frictions is that unemployment, wage bargaining, and vacancy posting, which are the main factors of any realistic labour market, play an important role. A number of papers (Chassamboulli and Palivos (2013), Chassamboulli and Palivos (2014), and Chassamboulli and Peri (2015)) investigate the effect of migration on labour market outcomes for skilled and unskilled workers, and analyse the differential effects on natives and (typically illegal) immigrants. Liu (2010) and Battisti et al. (2017) use a similar setup, but focus on welfare. The focus of these papers is on the analysis of equilibrium outcomes and not on economic fluctuations at business cycle frequencies. Papers that use the search and matching approach to analyse dynamics at business cycle frequencies focus on a large country, such as Braun and Weber (2016), who investigate regional effects of forced worker reallocation to Germany after the Second World War, and Clemens and Hart (2016), who model two-sided migration in Germany, but a use two-country model, where countries are equal in size. Kiguchi and Mountford (2017) focus on the U.S. and investigate labour market dynamics, but in their model (im)migration is an exogenous process and home-country-specific shocks do not trigger migration.<sup>1</sup>

This paper belongs to the second approach, i.e., it takes into account search and matching frictions explicitly. Its contribution is along several lines. First, unlike in most papers, migration in the model is endogenous and the migration decision is based on directed search, as in (Afonso and Gomes, 2014).<sup>2</sup> Second, it explores the effects of migration on the labour market of a small open economy. Third, the paper analyses the role of country size. The size of the country is important, because what is a small migration flow from the perspective of a large economy is a large flow from the perspective of a small economy, and can have a strong impact on the labour supply in a small economy. Fourth, the focus of the paper is on business cycle fluctuations, and the model includes sticky prices and wages, which is a more realistic setting for the

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<sup>1</sup>There is also ample empirical research on migration, but its focus has typically been on the effects on wages (Borjas, 2003), remittances, or public finances (see Borjas (1994) and Kerr and Kerr (2011) for a survey). Few recent papers that look at dynamics and causation are Boubtane et al. (2013), Furlanetto and Robstad (2016), and (Kiguchi and Mountford, 2017).

<sup>2</sup>Somewhat differently, Chassamboulli and Peri (2015) endogenise the search decision by assuming that workers receive an exogenous opportunity to migrate.

analysis of economic fluctuations at shorter frequencies. Finally, the paper assumes that all workers are equal, i.e., migration is not necessarily unskilled and is not illegal, which is in contrast to most papers cited above.

The main reason for assuming that native and immigrant workers are equal in terms of skills is that the paper investigates migration over the business cycle, not migration due to wars, climate change, political persecution, etc. To capture the free movement of labour within the European Union, it is not necessary or desirable to assume that migrants are either low-skilled or high-skilled. In addition, the model allows for the case where immigration can reverse after an adverse shock to the home economy and natives can emigrate. In such case, there is no a priori reason to believe that native emigrants will be unskilled. In small open economies, where multinationals play an important role, such assumptions are less realistic. The evidence for the U.K. (Dustmann et al., 2005), which is similar to Ireland in terms of the labour market openness, shows that the skill distribution of immigrants is similar to that of natives.<sup>3</sup> In addition, using segmented markets for foreign-born workers and natives would imply that firms post separate vacancies for foreigners and for natives, which would be discriminatory.

In this context, Ireland is particularly interesting, as it has maintained an integrated labour market with the U.K. for a long time (Fitzgerald and Kearney, 1999), a level of integration European Union countries are trying to emulate. In terms of economic migration Ireland is also interesting due to the strong presence of foreign multinationals that tend to source workers globally due to the type of skills they require.<sup>4</sup>

From the business cycle perspective, migration affects labour supply. Byrne and O'Brien (2017) show that migration played an important role for the labour force in Ireland and that a substantial part of labour force participation was cyclical, with immigration of foreigners during the boom, and emigration of both foreigners and natives during the recession. Similarly, Fitzgerald and Kearney (1999) argue that Ireland has always kept an integrated labour market with the UK, that this has led to the supply of labour that is more elastic than it would be in an economy with a closed labour market, and that this has led to a flatter Phillips curve.

Importantly, migration is not something that is specific to Ireland or small countries (Kerr and Kerr, 2011). For instance, Huart and Tchakpalla (2015) show that net migration in several European countries has exceeded one percentage point of the population. This is the case even in countries as large as Spain. Such large movements in population are unlikely to leave the domestic labour market unaffected and there is evidence that migration decreased the slope of the Phillips curve even in a country as large as Spain (Bentolila et al., 2008).

The main findings of the paper are, first, that responses to country-specific shocks become stronger in the presence of migration. The reason for this is that after a beneficial shock to the domestic economy, workers from abroad immigrate to benefit

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<sup>3</sup>Note that the issue of the skill composition is not settled empirically. The cited evidence from the U.K. is for instance in line with Peri (2006), but Card (2005) argues for the U.S. that this is not the case.

<sup>4</sup>There is little evidence that immigration to Ireland has been either only skilled or only unskilled. Bergin and Kearney (2007) argue that the major part of immigration to Ireland in the 1990s was high-skilled. Roeder (2011) argues that the immigration from Eastern Europe during the building boom in mid-2000s was mostly unskilled, and Barrett et al. (2006) argue that even skilled immigrants have searched for low-skilled jobs.

from the expansion. The expansion of home labour supply through immigration leads to a lower increase in negotiated wages (similarly as in Chassamboulli and Palivos (2013) and Chassamboulli and Palivos (2014) for unskilled immigrants), which in turn improves firm profitability and amplifies vacancy posting. The simultaneous presence of searching workers and more vacancies does not congest the matching process on the labour market, which leads to faster and higher employment and output. Stronger increases in employment and lower increases in wages attenuate the Phillips curve relation.

Second, unemployment rises after an exogenous increase in immigration, as in Kiguchi and Mountford (2017). However, if wages fall sufficiently so that firms post vacancies and new arrivals find jobs, the unemployment increase is short-lived. Moreover, negative fiscal consequences of paying unemployment benefits are quickly offset by higher labour tax revenues.

Third, if an economy is relatively small and has labour markets open to a large pool of potential immigrants, then, all else equal, labour supply from immigration is more elastic. This is because most of the labour adjustment to immigration happens in the home economy rather than abroad.

The paper is structured as follows. Section 2 presents some stylised facts on migration in Europe. Section 3 provides the details of the model. Section 4 describes the calibration of the model and section 5 discusses the main results. Section 6 concludes.

## 2 Stylised facts

This section describes some stylised facts about migration in Europe. The focus of the description is to show that economic migration is related not only to the long-run differences in economic conditions, but also to the state of the business cycle.

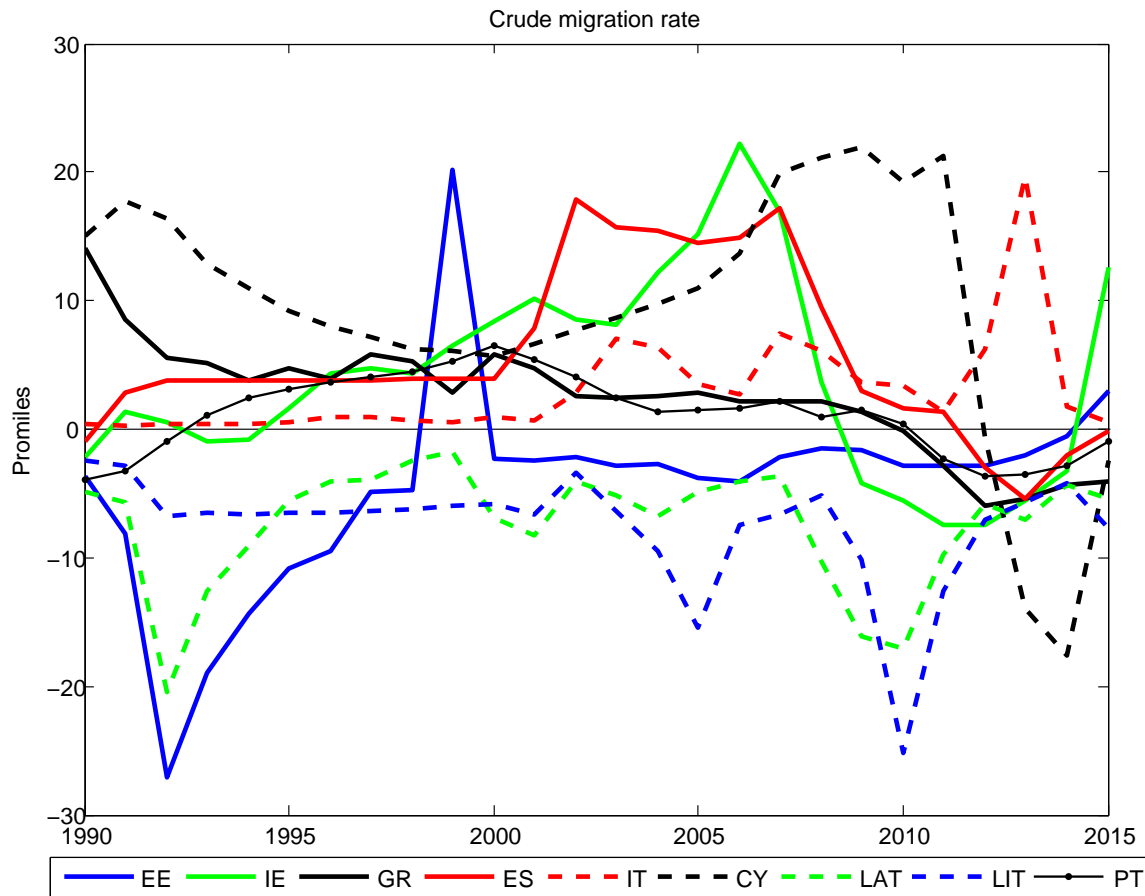
Figure 1 plots the crude rate of net migration for a set of European countries that have been most severely hit by the recession in 2008-2009, or subsequently by the sovereign debt crisis.<sup>5</sup> There are two main cyclical features in this figure. First, net immigration to countries that experienced a strong expansion in mid-2000s increased substantially and reached proportions that exceed 1% of the population.<sup>6</sup> This is the case both for relatively small countries like Ireland or Cyprus, as well as for medium-sized countries such as Spain or Portugal. The strong net immigration reversed to strong net emigration when the business cycle reversed. These findings are similar to the findings in Huart and Tchakpalla (2015), who find a mirror image relation between unemployment rates in a particular country and migration. Second, there are countries that experience net emigration or net immigration on average, but the net migration rates nevertheless fluctuate with the cycle (e.g., the Baltic states).

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<sup>5</sup>The crude rate of net migration (plus adjustment) is taken from the Eurostat and is the ratio of net migration during the year to the average population in that year, expressed per thousands of persons (the value of 10 therefore means 1% of the average population). The net migration rate (plus adjustment) is the difference between the total change in the population and its natural change.

<sup>6</sup>Note that migration flows in Figure 1 include some exceptional cases (e.g., Italy), where factors not related to business cycles (wars, climate change) have led to strong migration flows.

FIGURE 1. Crude net migration rate in selected countries.



Notes: The crude rate of net migration (plus adjustment) is the ratio of net migration during the year to the average population in that year, expressed per thousands of persons. The net migration rate (plus adjustment) is the difference between the total change in the population and its natural change. EE - Estonia, IE - Ireland, GR - Greece, ES - Spain, IT - Italy, CY - Cyprus, LAT - Latvia, LIT - Lithuania, PT - Portugal. Source: Eurostat.

A somewhat more formal evidence is provided in Table 1, which reports correlation coefficients between the crude net migration rate and real GDP in the EU countries, together with the maximum peak-to-trough change in the cyclical component of crude migration.<sup>7</sup> Two regularities can be observed. First, wherever the correlation between net migration and real GDP is statistically significantly different from zero, it is also positive and large. This is the case in nine countries out of 23.<sup>8</sup> Second, countries that have procyclical migration tend to be countries that are small and/or open to a large potential pool of immigrants (e.g., because of lower language barriers, for example Spain and Latin America).

<sup>7</sup>The data are on the annual frequency and the cyclical components were obtained using the Hodrick-Prescott filter with the smoothing constant of 100. For most countries the data are for the period between 1995-2015; for Denmark, Germany, France, and Finland data begin in 1990, and for Luxembourg and Malta in 2001.

<sup>8</sup>The correlation is negative (not statistically significant) in five countries and positive, but not statistically significant in nine.



TABLE 1. Correlation between net migration and real output and peak-to-trough changes

| Country     | Correlation | p-value | $\Delta$ Peak-to-trough (p.p. of pop.) |
|-------------|-------------|---------|--|
| Belgium     | 0.20        | 0.37    | 0.52                                   |
| Denmark     | 0.32        | 0.10    | 0.42                                   |
| Germany     | 0.27        | 0.20    | 0.70                                   |
| Estonia     | -0.21       | 0.34    | 3.38                                   |
| Ireland     | 0.87        | 0.00    | 2.23                                   |
| Greece      | 0.63        | 0.00    | 0.54                                   |
| Spain       | 0.51        | 0.02    | 1.23                                   |
| France      | 0.50        | 0.02    | 0.24                                   |
| Italy       | -0.20       | 0.38    | 1.89                                   |
| Cyprus      | 0.79        | 0.00    | 2.83                                   |
| Latvia      | 0.54        | 0.01    | 1.25                                   |
| Lithuania   | 0.37        | 0.09    | 1.99                                   |
| Luxembourg  | -0.09       | 0.75    | 0.62                                   |
| Hungary     | 0.30        | 0.19    | 0.18                                   |
| Malta       | 0.19        | 0.49    | 0.63                                   |
| Netherlands | 0.51        | 0.02    | 0.42                                   |
| Austria     | -0.17       | 0.46    | 0.73                                   |
| Poland      | 0.16        | 0.49    | 0.09                                   |
| Portugal    | 0.75        | 0.00    | 0.43                                   |
| Romania     | -0.19       | 0.41    | 2.42                                   |
| Slovenia    | 0.66        | 0.00    | 0.90                                   |
| Slovakia    | 0.25        | 0.19    | 0.43                                   |
| Finland     | 0.18        | 0.39    | 0.18                                   |

In addition, many of the countries where correlation between net migration and real GDP is high and positive at cyclical frequencies are also the countries where changes in the net migration flow over the business cycle has exceeded 1% of the population (e.g., Ireland, Latvia, Cyprus, Spain). Even in large countries that have not been severely affected by the recent crisis and where the correlation over the business cycle is positive and significant (France), fluctuations in net migration can be in excess of 0.2% of the population. Note that migrants are typically of working age (Barrell et al., 2007), which means that the numbers reported above are conservative estimates of the impact of migration on the labour force (see also Byrne and O'Brien (2017)). This indicates that in many countries, large and small, net migration at cyclical frequencies plays an important role in determining labour supply.

### 3 Model

This section explains in detail the labour-market part of the model and the modelling of migration. The remainder of the model is a standard New Keynesian small open



economy model with tradable and non-tradable sectors, import-content of exports and a monetary union assumption.<sup>9</sup>

### 3 Labour market

The labour market in the model is based on the standard Diamond-Mortensen-Pissarides search and matching framework. The key features of this framework are that (1) there are unemployed workers and unfilled vacancies in equilibrium, (2) that finding work takes time, and (3) wages are determined by bargaining, which depends on labour market conditions.

### 3 Matching and labour market flows

The matching process is modelled using a Cobb-Douglas matching function, where  $m_t$  is the number of matches,  $v_t$  is the number of vacancies, and  $s_t$  is the number of searching workers.  $\phi > 0$  is the efficiency of the matching process and  $0 < \mu < 1$  is the elasticity of the matching function. The matching function is:

$$m_t = \phi s_t^\mu v_t^{1-\mu}, \quad (1)$$

the probability of a worker to find a job,  $p_{W,t}$  is:

$$p_{W,t} = \frac{m_t}{s_t} = \phi \left( \frac{v_t}{s_t} \right)^{1-\mu}, \quad (2)$$

and the probability of a firm to find the worker,  $p_{F,t}$  is:

$$p_{F,t} = \frac{m_t}{v_t} = \phi \left( \frac{v_t}{s_t} \right)^{-\mu}. \quad (3)$$

### 3 Population and migration

Because of migration, the total population of the economy is not constant over the business cycle. Population at the end of the period,  $P_{op,t}$ , is defined as:

$$P_{op,t} = n_{H,t} + n_{F,t} + u_{H,t} + u_{F,t}, \quad (4)$$

where  $n_{H,t}$  is the number of employed natives,  $n_{F,t}$  is the number of employed foreigners,  $u_{H,t}$  is the number of unemployed natives and  $u_{F,t}$  is the number of unemployed foreigners.

The total number of employed workers,  $n_t$ , evolves as:

$$n_t = (1 - \delta_x)n_{t-1} + m_t, \quad (5)$$

where  $\delta_x$  is the exogenous separation rate.<sup>10</sup>

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<sup>9</sup>Because the remainder of the model is a standard small open economy model, I do not report the full equations in the main text. The main derivations and the changes compared to the model of Clancy and Merola (2016) are provided in the appendix.

<sup>10</sup>Dynare notation is used throughout the paper (state variables that have been determined at the end of the previous period have the time index  $t - 1$ ).

Searching workers in the home economy consist of searching natives,  $s_{H,t}$ , and searching foreigners,  $s_{F,t}$ , so that  $s_t = s_{H,t} + s_{F,t}$ . Searching natives consist of part of the total native population (which is standardised to one, as is typical in the literature) that is not employed at the end of the previous period,  $1 - n_{H,t-1}$ , plus all natives that have lost their jobs at the beginning of the period:

$$s_{H,t} = 1 - n_{H,t-1} + \delta_x n_{H,t-1}. \quad (6)$$

Foreign searching workers consist of those foreign workers who were unemployed in the previous period, those foreign workers who have lost the job at the beginning of the period, and those who have immigrated at the beginning of the period,  $u_{MIG,t}$ .<sup>11</sup>

$$s_{F,t} = u_{F,t-1} + \delta_x n_{F,t-1} + u_{MIG,t}. \quad (7)$$

The number of native and foreign unemployed at the end of the period is then equal to the number of searching workers (natives or foreign) in the beginning of the period, minus those who have found work during the period, where native and foreign workers match in proportion to their shares in the total of searching workers. This gives the following equation for unemployed, where  $i \in [H, F]$ :

$$u_{i,t} = s_{i,t} - m_t \frac{s_{i,t}}{s_t}. \quad (8)$$

The laws of motion for native and foreign employed are therefore

$$n_{i,t} = (1 - \delta_x) n_{i,t-1} + m_t \frac{s_{i,t}}{s_t}. \quad (9)$$

Given the small open economy setup, only the labour market part of the foreign economy is fully specified in terms of search and matching. This is needed in order to investigate the effects of the relative sizes of home and foreign labour markets on the Home economy. In particular, the number of employed natives abroad,  $n_t^*$ , evolves analogously to the number of employed natives in home and has an analogous matching function as in equation 1 and analogous definitions of matching probabilities as in equations 2 and 3.<sup>12</sup> The law of motion for employed workers abroad is:

$$n_t^* = (1 - \delta_x) n_{t-1}^* + m_t^*. \quad (10)$$

The number of searching workers abroad,  $s_t^*$  is defined as:

$$s_t^* = \theta - n_{t-1}^* + \delta_x n_{t-1}^* - n_{F,t-1} - u_{F,t-1} - u_{MIG,t}, \quad (11)$$

where  $\theta$  is the (relative) size of the foreign economy. The number of unemployed abroad at the end of the period is then  $u_t^* = s_t^* - m_t^*$ .

Foreign and home labour markets are linked through the last three terms in equation 11 that account for past and present migration. Those who emigrated from the foreign labour market in the past are either employed or unemployed in the home labour market, and the current net migration is  $u_{MIG,t}$ . If both markets are of equal size ( $\theta = 1$ ), then

<sup>11</sup>Note that  $u_{MIG,t}$  is the net migration flow, i.e., the addition to the population from migration. It is equal to zero in the steady state and can be positive or negative outside the steady state.

<sup>12</sup>Because the home economy is a net recipient of immigration, there are no immigrants in the foreign economy.

migration to the home labour market affects the foreign labour market to the same extent as it affects the home labour market. The assumption that the home economy is relatively small ( $\theta$  is large) implies that developments in home affect labour markets in foreign only to the extent of its relative size (i.e., the effect is small).

### 3 Value functions

The value functions are defined in monetary terms, per person, and after the matching process has been completed.

**Value functions of a worker.** A worker can be either employed, in which case she gives up leisure to work  $h_t$  hours, for which she receives an hourly wage  $w_t$ . In the case of separation, which occurs with an exogenous probability  $\delta_x$ , a worker is allowed to search for the job immediately and, if the search is not successful, end up with the value of being unemployed,  $U_t$ . Without breakup, a worker continues the employment relationship and receives the value of being employed,  $E_t$ . In case of unemployment, government distributes unemployment benefits,  $b$  at the end of the period. The value of being employed is therefore:

$$E_t = (1 - \tau_t^{wh})w_t h_t - \frac{\chi}{\lambda_t} \frac{h_t^{1+\zeta}}{1+\zeta} + \beta \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} (\delta_x(1 - p_{W,t+1})U_{t+1} + (1 - \delta_x(1 - p_{W,t+1}))E_{t+1}), \quad (12)$$

and the value of being unemployed is

$$U_t = b + \beta \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} (p_{W,t+1}E_{t+1} + (1 - p_{W,t+1})U_{t+1}). \quad (13)$$

In equations 12 and 13,  $\lambda_t = c_t^{-\gamma}$  is the marginal utility of the household and  $\beta \frac{\lambda_{t+1}}{\lambda_t}$  is the stochastic discount factor of the household. Equation 12 states that the value for a worker of being in an employment relationship is equal to the wage income in the current period,  $w_t h_t$ , net of taxes paid by households,  $\tau^{wh}$ , minus the disutility of working (measured in units of consumption),  $\frac{\chi}{\lambda_t} \frac{h_t^{1+\zeta}}{1+\zeta}$ , plus the discounted value of either continuing in the employment relationship in the next period, or becoming unemployed. Equation 13 states that the value of being unemployed is the sum of unemployment benefits received during the period,  $b$ , plus the discounted value of the status in the next period. The latter can be employment, which occurs with the probability of finding a job,  $p_{W,t}$ , or unemployment, in the case where no job is found.

Unemployment benefits are constant and determined as a proportion of the steady-state wage and hours worked in the home economy. This replacement ratio,  $rr$ , determines the fraction of the average steady-state wage that an unemployed worker receives as unemployment benefit.<sup>13</sup>

**Value functions of a firm.** We assume that there are intermediaries on the labour market, called labour firms, who hire workers by posting vacancies and then sell labour

<sup>13</sup>This should be viewed more broadly than just a replacement ratio and should include any benefits that immigrant workers receive in case of not working (including all social benefits).

services to intermediate goods firms at a competitive price.<sup>14</sup> The assumption is that there is a continuum of labour firms, with one worker per labour firm. Once a worker is hired, she works  $h_t$  hours, which are transformed by the labour firm into labour services,  $y_t^h$ :

$$y_t^h = h_t^{\alpha_H}, \quad (14)$$

where  $\alpha_H < 1$ .

Each labour firm sells labour services to the intermediate goods firm at the price  $x_t$  and pays the worker an hourly wage  $w_t$ , which includes the corresponding labour tax borne by firms,  $\tau^{wf}$ . Having a vacancy open entails a cost. This cost,  $\psi$ , is a per-period cost.<sup>15</sup> The value of having a worker,  $J_t$ , is defined as

$$J_t = x_t h_t^{\alpha_H} - (1 + \tau_t^{wf}) w_t h_t + \beta \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} (1 - \delta_x) (J_{t+1}), \quad (15)$$

and the value of having a vacancy,  $V_t$ , is defined as

$$V_t = -\psi + p_{F,t} J_t + \beta \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} ((1 - p_{F,t}) V_{t+1}). \quad (16)$$

Equation 15 is the value for the firm of having a worker, which consists of the revenues from selling labour services to intermediate goods firms,  $x_t h_t^{\alpha_H}$ , minus the gross wage cost paid to the worker,  $(1 + \tau_t^{wf}) w_t h_t$ , plus the discounted value of having a job in the next period, if there is no break-up in the employment relationship,  $(1 - \delta_x) J_{t+1}$ . Equation 16 specifies the value of having a vacancy open as the per-period cost, plus the value of having a worker if there is a match (which occurs with the probability  $p_{F,t}$ ). Workers become productive immediately.

Labour firms enter the market (post vacancies) as long as the prospect of obtaining a worker exceeds the costs of having the vacancy open. In equilibrium, the value of having a vacancy is  $V_t = 0$  in every period.<sup>16</sup> This reduces equation 16 to the so-called free entry condition:

$$\psi = p_{F,t} J_t. \quad (17)$$

### 3 Wages and hours

Wages and hours are determined using a wage norm as in Hall (2005). The setup explained below has the advantage that it nests the efficient Nash bargaining (Trigari, 2009) as a special case.

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<sup>14</sup>This modelling device is not essential, as the remainder of the model uses price setting as in Rotemberg (1982), but I use it because it helps to aggregate labour services across the tradable and non-tradable sector.

<sup>15</sup>Such cost can be interpreted as the cost of advertising, but also as an opportunity cost of foregone income.

<sup>16</sup>With a continuum of labour firms and one worker per firm, this amounts to the assumption that the number of new vacancies is equal to the number of labour firms that have entered the market.

**Efficient Nash bargaining.** The standard approach to splitting the surplus created in the match is by assuming each of the parties involved (firms and workers) have some bargaining power and that they bargain over wages and hours simultaneously. In this process, the Nash product is maximised.<sup>17</sup> If  $\eta_B$  is the bargaining power of workers, wages and hours are determined by solving the following problem:

$$\max_{w_t, h_t} (E_t - U_t)^{\eta_B} J_t^{1-\eta_B}, \quad (18)$$

which results in

$$\eta_B(1 - \tau_t^{wh})J_t = (1 - \eta_B)(1 + \tau_t^{wf})(E_t - U_t). \quad (19)$$

Hours are determined as

$$x_t \alpha_H h_t^{\alpha_H - 1} = \frac{\chi}{\lambda_t} h_t^\zeta \frac{(1 + \tau_t^{wf})}{(1 - \tau_t^{wh})}, \quad (20)$$

where  $x_t$  is the real price at which labour firms sell their labour services to intermediate goods firms. Note that hours worked do not depend on wages, and that they depend on the marginal disutility of work for a household member, not the household as a whole (the value function itself depends on the disutility of the entire household). Equation 20 states that hours are chosen so that the worker's disutility of working an additional hour has to be equal to the additional revenues of the firm from this extra work hour. Because the amount of labour services that are negotiated between firms and workers does not depend on wages, wages play no allocative role for labour in such a setup. The only role of wages is that they split the surplus between workers and firms.

Taxes enter both the determination of wages, equation 19, and the determination of hours, 20. When taxes change, this will be taken into account during wage bargaining. In particular, the side that will be taxed more (less) will demand a larger (smaller) share of the surplus in order to compensate for the share taken by the government.

**Wage norm.** In the above framework, wages are renegotiated every period and are completely flexible. Typically, wages in such settings will tend to be too volatile at the expense of too little volatility of (un)employment (this is essentially the core of the Shimer (2005) critique of matching models). Hall (2005) proposed an alternative method of wage determination. Following Hall, the aggregate wage,  $w_{Hall}$ , is determined using a simple rule that is a weighted average between a 'wage norm' (which is typically a steady-state wage,  $\bar{w}$ , or previous-period wage,  $w_{t-1}$ ), and the Nash wage determined in the current period:

$$w_{Hall,t} = \lambda w_t + (1 - \lambda)\bar{w}. \quad (21)$$

Hours can still be chosen efficiently between firm and worker, as in equation 20. Note that wages are still flexible in the Hall framework in the sense that all wages are reset to a new value every period. The rigidity arises because they are not reset to the full extent that agents desire (parameter  $\lambda$  governs the degree of such real rigidity). This results in typically stronger responses of (un)employment to shocks.

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<sup>17</sup>This is called efficient Nash bargaining (Trigari, 2009), as it is efficient from the point of view of individual. Note that the outcome is not necessarily efficient for the economy as a whole.

For consistency, the number of vacancies posted by firms when wages are rigid is not determined by the value function of the firm based on the currently-bargained Nash wage,  $J_t(w_t)$ , but by the value function depending on the aggregate wage,  $J_t(w_{Hall,t})$ .

**Taxes.** Labour taxes paid by households or firms can be changed by the government, which is modelled as an AR(1) process. Labour taxes paid by firms evolve as:

$$\tau_t^{wf} = (1 - \rho_{\tau^{wf}})\overline{\tau^{wf}} + \rho_{\tau^{wf}}\tau_{t-1}^{wf} + \varepsilon_{\tau^{wf},t} \quad (22)$$

and labour taxes paid by households evolve as

$$\tau_t^{wh} = (1 - \rho_{\tau^{wh}})\overline{\tau^{wh}} + \rho_{\tau^{wh}}\tau_{t-1}^{wh} + \varepsilon_{\tau^{wh},t}, \quad (23)$$

where the bar over the tax rate indicates the steady-state tax rate,  $\rho_{\tau^{wf}}$  and  $\rho_{\tau^{wh}}$  determine the persistence of tax shocks, while  $\varepsilon_{\tau^{wf},t}$  and  $\varepsilon_{\tau^{wh},t}$  are shocks to taxes paid by firms and households, respectively.

### 3 Migration

The typical assumption in a standard search and matching model is that unemployment is insured by means of a large representative households that pool resources, following Merz (1995) and Andolfatto (1996).<sup>18</sup> Migration brings an additional complication in that migrant workers can either belong to a foreign household to which they send remittances (Mandelman and Zlate (2012) model this explicitly and assume consumption of such workers is determined by the foreign household) or they integrate to the home economy. To keep the model tractable along the lines of Merz (1995) and Andolfatto (1996), the assumption is that all migrant workers become members of the home representative household. Consumption is determined by the household as a whole.<sup>19</sup>

### 3 Directed search and migration decision

The model of net migration here uses the directed search approach (see Afonso and Gomes (2014) or Gomes (2015)). According to this approach, unemployed workers can decide in the beginning of every period in which labour market they will search. If an unemployed worker decides to search in her home labour market, then she can either remain unemployed with probability  $(1 - p_{W,t})$ , in which case she receives the value of being unemployed in the home market, and if the job search is successful, which occurs with probability  $p_{W,t}$ , she receives the value of being employed in the home country. If the unemployed worker decides to move abroad, then the situation is analogous, just that probabilities and values are those that apply in the foreign labour market. The unemployed will therefore relocate as long as the expected value of being on the home labour market is not the same as the expected value of being on the foreign labour market.

<sup>18</sup>The reason for such assumption is that otherwise the model becomes intractable, as individual's consumption depends on the entire employment history.

<sup>19</sup>Note that the assumption that immigrants are excluded from holding assets is unrealistic in the EU, as deposits from a bank account located anywhere within the Single Euro Payments Area can be used for saving or payments.

I assume that the value functions abroad have the same functional forms as on the home labour market (equations 12 and 13), but with everything treated as exogenous except the matching probabilities. The latter are only marginally affected by migration due to the small relative size of the home economy, which has almost no effect on the foreign labour market. Vacancies and wages abroad are assumed to be exogenous. This gives the following condition for directed search that determines migration (asterisks denote the variables determined in the foreign labour market):

$$(p_{W,t}E_t + (1 - p_{W,t})U_t) = \varepsilon_{MIG,t}\xi_{L,t} (p_{W,t}^*E_t^* + (1 - p_{W,t}^*)U_t^*). \quad (24)$$

Labour market equilibrium is determined through migration that affects domestic probabilities of finding a job. For example, if labour market conditions in the home economy become better than abroad, the value functions on the left-hand side of the equation increase (in particular the value of being employed increases by more than the value of being unemployed), while the right-hand side of the equation remains (almost) constant. The only way that equation 24 can still hold is that the matching probability of the worker at home decreases. This occurs through the increased migration to the home economy.

When the home economy is relatively small, then the adjustment is almost exclusively on the side of the home economy. For example, a small increase in home wages relative to foreign attracts a number of workers from abroad that is large relative to the size of the home economy (even if it is small relative to the size of the foreign economy). To prevent such large migration flows, the term  $\xi_{L,t}$  is introduced to facilitate the calibration of the volatility of migration. It is defined as  $\xi_{L,t} \equiv (1 - \xi_L(P_{op,t} - \bar{P}_{op})/\bar{P}_{op})$ , where  $\bar{P}_{op}$  is steady-state population. This term drives a wedge between the value of being abroad and the value of being in the home economy when the home population increases due to immigration. The main advantage is that as  $\xi_L \rightarrow \infty$ , the migration channel can be shut down and the model becomes a standard search and matching model without migration. Note that the term  $\xi_L$  has a similar role as the elasticity of the debt-elastic interest rate premium in Schmitt-Grohé and Uribe (2003) and that the function  $\xi_{L,t}$  can be set such that no additional assumptions are needed when migration flows reverse in the presence of large shocks.<sup>20</sup>  $\varepsilon_{MIG,t}$  is an exogenous shock to migration.

## 4 Calibration

The model is calibrated to Ireland as follows. The Great Ratios (shares of investment, imports, re-exports, government spending) in the steady-state are matched to correspond to those in Clancy and Merola (2016) and in Lozej et al. (2017).

The labour market part of the model is calibrated so that Ireland is a net recipient of migration flows. This is achieved by reducing the steady-state wage level abroad, so that the net immigration to Ireland is 10% of employment, in line with the labour force participation rates described in Byrne and O'Brien (2017). The separation rate,

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<sup>20</sup>The reduced-form migration costs can be rationalised using a more micro-founded approach from the spatial economics literature, see Moretti (2011) for an overview and Braun and Weber (2016) or Clemens and Hart (2016) for recent examples. It can be shown that the reduced form approach can be calibrated so that it yields almost the same dynamic responses to shocks as the framework of e.g. Braun and Weber (2016).



$\delta_x$ , is calibrated to match the 5% unemployment rate in the steady state. The matching probability for workers is set to 0.16, based on the estimates for Ireland from Elsby et al. (2013).<sup>21</sup> Lacking a reliable estimate, the quarterly matching probability for firms is set to 0.7, based on the estimates for the Netherlands of Van Ours and Ridder (1992), which is lower than the relatively high monthly estimate of 0.7 for the U.S. by den Haan et al. (2000).<sup>22</sup> The cost of posting a vacancy,  $\psi$ , and the matching efficiency,  $\phi$ , are backed-out to achieve these probabilities. The elasticity of the matching function with respect to unemployment,  $\mu$ , is set to 0.5, in line with the midpoint of the estimates reported in Petrongolo and Pissarides (2001). The weight of leisure in the utility function is calibrated so that hours per worker in the steady state are 1, which means the number of employed in the economy is also the number of effective hours worked. Replacement ratio for unemployment benefits is set to 0.4, which is lower than 0.6 reported for a two-member family (Department of Finance, 2013). The reason is that the lower replacement ratio attempts to take into account that migrants are not entitled to unemployment benefits, but they may be entitled to some social security benefits (e.g., benefits related to child support). The bargaining power of workers is set to the standard value of 0.5.<sup>23</sup> The parameter that determines the persistence of wages in the Hall (2005) wage norm,  $\lambda$ , is set to 0.9, implying that wages are close to the fully-flexible wages that would be negotiated in that period, in line with the findings in Lydon and Lozej (2016). The utility function is parametrised in line with Clancy et al. (2016) and the standard values from the literature. The (inverse of) the intertemporal elasticity of substitution of consumption is set to 2, habit formation to 0.4, and the inverse Frisch labour supply elasticity to a standard value of 2. The details are reported in Table 2 in the Appendix.

The parameter  $\xi_L$  has been set such that migration flows are somewhat stronger than those reported by Fitzgerald and Kearney (1999), who obtain that a 1% increase in unemployment increases migration by about 0.7%. The reason for choosing calibration that yields somewhat stronger migration flows is that since 2004, Ireland has opened its labour markets to immigration from the EU, which had a substantial impact (Byrne and O'Brien, 2017). Because of this, I calibrate  $\xi_L$  such that for a 1 p.p. increase in immigration there is a somewhat smaller initial increase in unemployment of about 0.8 p.p. (and a small initial increase in employment, as workers can match contemporaneously).

Adjustment costs and indexation parameters in the model of Clancy and Merola (2016) have been adjusted to account for greater persistence induced by the introduction of migration. In particular, indexation parameters for non-tradable goods prices, import goods prices, and export goods prices are set to 0.1. The parameters governing the elasticity of substitution between home-produced and imported final consumption goods are set to 2.5 (Clancy et al., 2016) and markups for all goods to 10%. Production functions are calibrated so that the labour share in the non-tradable sector is higher, in line with Clancy and Merola (2016) and Clancy et al. (2016). Moreover, investment share has been matched using the labour intensity of the non-tradable

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<sup>21</sup>Elsby et al. (2013) estimate the monthly job finding rate for Ireland of 5.9%, which, assuming that this rate is constant over the quarter, is transformed into quarterly probability  $p_W$  using  $p_W = 1 - \exp(-0.059 * 3)$ .

<sup>22</sup>None of the results of the paper are materially affected if this rate is set to lower values. The results with  $p_W = 0.3$  are available upon request.

<sup>23</sup>Given the elasticity of the matching function, this satisfies the Hosios condition.

production function. The full details of the calibration are reported in Table 3 in the Appendix.

## 5 Results

### 5 Immigration shock

This section shows the effects of an exogenous immigration shock on the home economy. This shock can be viewed as a stylised representation of any shock that is exogenous to the domestic economy, but leads to immigration.<sup>24</sup> The reason for choosing this shock is that it permits the comparison of the outcomes with several recent papers, two empirical (Latif (2015) and Furlanetto and Robstad (2016)), and one theoretical (Kiguchi and Mountford, 2017). Given that these papers reach somewhat different conclusions, this section also provides some notion regarding how the calibration of the model matters for the main results.

Figures 2 and 3 show the results of an immigration shock that increases the population by one percent. Figure 2 displays the responses of the aggregate and labour market variables, while Figure 3 displays per-capita variables and some of the fiscal variables associated with the labour market, such as the aggregate labour tax revenues, aggregate unemployment benefits, and the net tax revenues (labour taxes from households and firms minus unemployment benefits). Each figure plots two lines, one with benchmark calibration (black line) where the job finding probability is as estimated by Elsby et al. (2013) for Ireland, and one where the job finding probability is high, as estimated by den Haan et al. (2000) for the U.S. (dashed red line).

Immigration increases aggregate output and consumption in the short run, because immigrants increase domestic demand and domestic production. Aggregate imports increase because of the increase in aggregate consumption. Aggregate investment decreases because the additional aggregate output does not suffice for financing additional aggregate consumption and because labour has become more abundant and relatively cheaper than capital. Exports increase because the decrease in domestic wages lowers prices and improves external competitiveness. Immigration increases the unemployment rate on impact under both calibrations.

The increase in unemployment in the case when matching probability for workers is low (the benchmark case) is relatively sharp on impact, but also drops relatively quickly. The reason is that immigration causes the probability that firms will find a worker to increase. Firms respond to this by posting more vacancies (but not so much that the probability of finding a worker would decrease). Because there are both more vacancies and more unemployed workers, there is less congestion in the matching process and employment increases. When the matching probability for workers is high, the initial increase in unemployment is lower (and the increase in employment higher), but unemployment persists for longer. The reason for this seemingly counter-intuitive result is that wages do not drop as much when matching probability for workers is high to start with, because workers have a more valuable outside option and are able to prevent a strong wage decrease during wage negotiations. Lower wage decrease implies that firms' profits do not increase as much and they post less vacancies. As a result,

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<sup>24</sup>The shock is implemented as a decrease in the expected value of being in the foreign labour market,  $(p_{W,t}^* E_t^* + (1 - p_{W,t}^*) U_t^*)$ , see equation 24.

employment quickly returns to initial levels and unemployment persists. Moreover, a lower drop in wages also implies a lower drop in prices and therefore lower gains in terms of competitiveness, which is reflected in lower increases in exports and GDP.

The main findings presented here are in line with the findings in Kiguchi and Mountford (2017) where they assume that immigrant workers begin as unemployed. The finding that wages decrease and output increases after an immigration shock is also in line with the mechanism reported in Borjas (2003), as well as with the findings of Furlanetto and Robstad (2016) for Norway. However, they also find that after an immigration shock in Norway, labour force participation increases and unemployment decreases. While labour force participation increases in the model presented here, unemployment increases initially for a short period, which is more in line with the findings of Latif (2015) for Canada.<sup>25</sup> Note, however, that when the wage decrease is stronger (as is the case under the benchmark calibration), unemployment rate in the model does decrease and that this happens well before population level returns to its initial level.

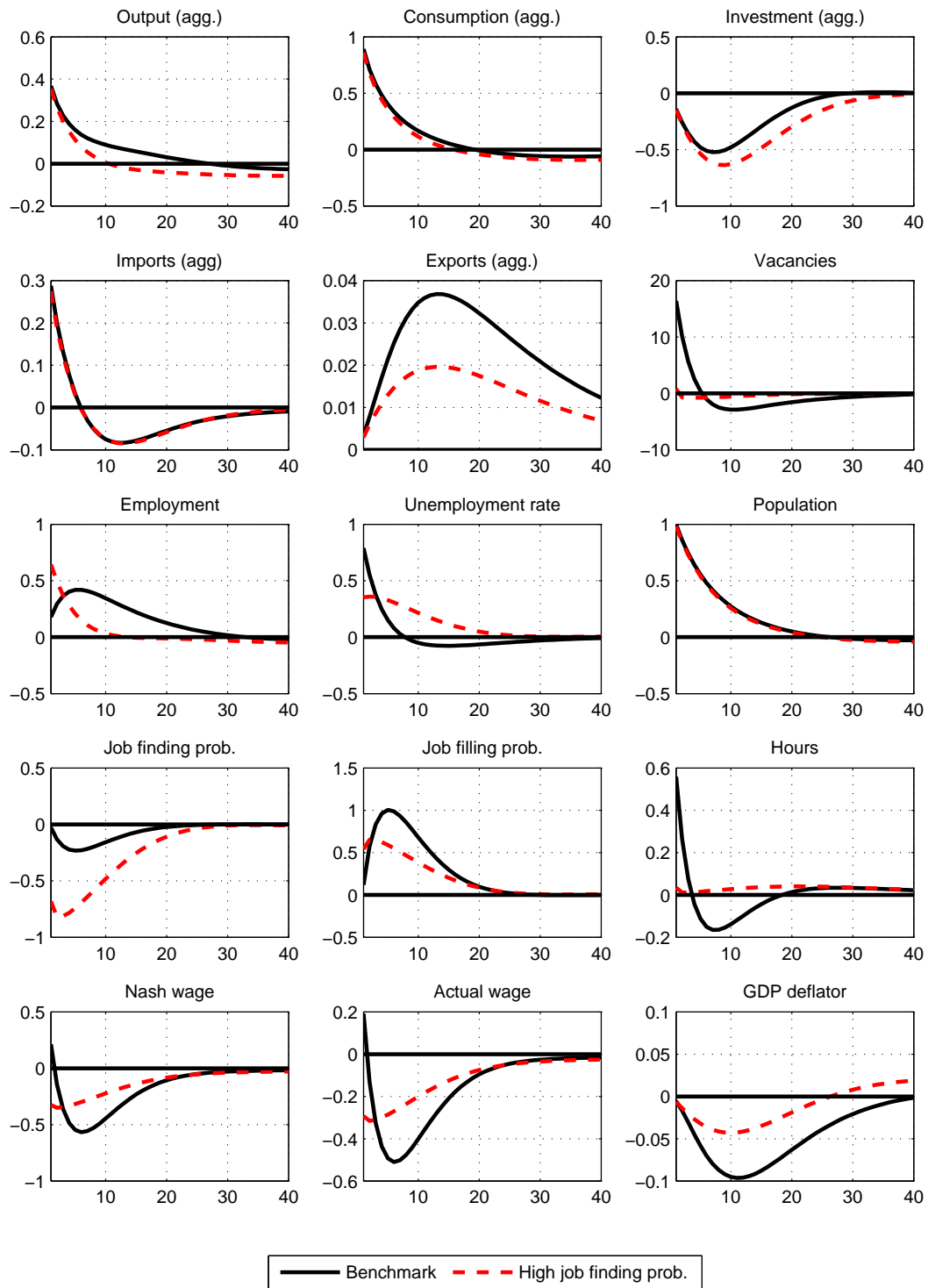
Note how the immigration shock affects the relation between (un)employment and the price level (the Phillips curve). Prices decrease persistently when employment increases and unemployment rises only temporarily. This is not surprising, given that immigration puts downward pressure on wages. Fitzgerald and Kearney (1999) for instance discuss the weakening of the Phillips curve relationship in Ireland due to migration flows. Bentolila et al. (2008) show that the same mechanism is at work in Spain. The model is therefore able to replicate an empirical regularity observed in economies with significant migration.

Figure 3 shows the responses of some fiscal variables that can be directly related to the labour market. Tax collections, either from firms or from households, follow the paths of wages and hours, as the increase in employment is not sufficiently strong to undo the fall in wages and hours. The net effect is a deterioration of net government revenues in the short run under both calibrations. Note however that this decrease in labour-related tax revenues is mostly due to the drop in wages, which affects *all workers*, indigenous and immigrant. The sharp initial increase in unemployment benefits disappears relatively quickly and turns negative under the benchmark calibration. Moreover, under the benchmark calibration higher employment level in the medium run offsets the decrease in wages, which improves tax collection. After about three years, net tax revenues become positive and persist for several years. This implies that fiscal costs related to immigration may be relatively short-lived if immigrants find work quickly.

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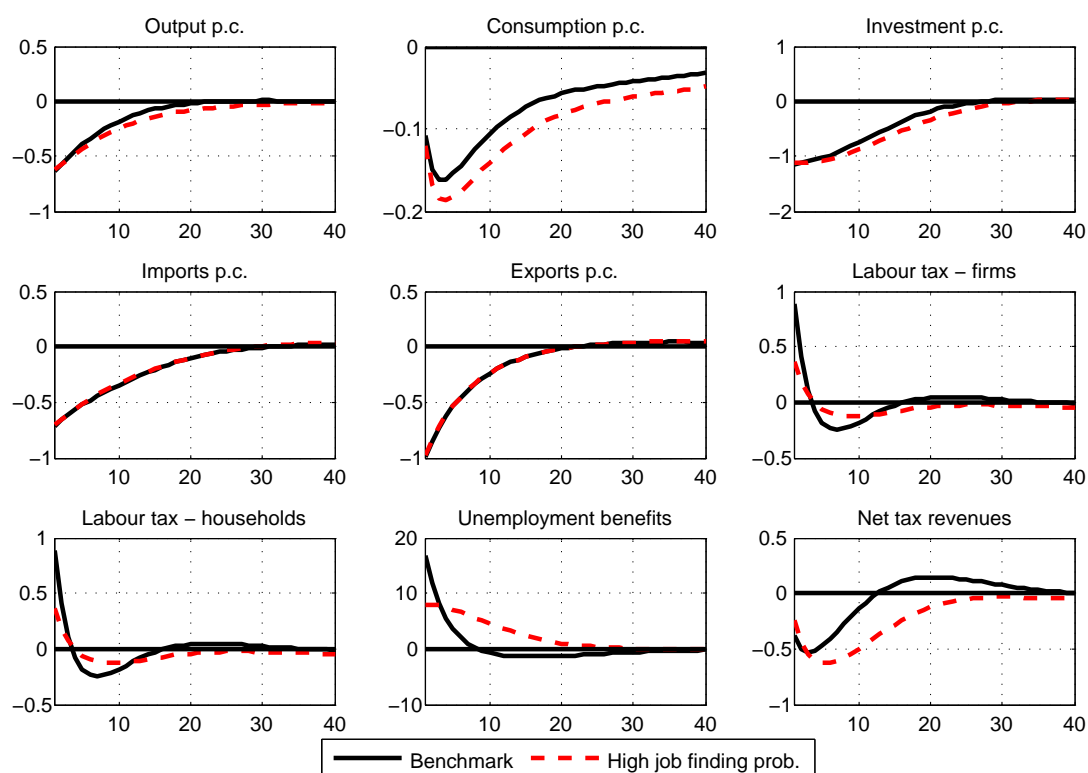
<sup>25</sup>Furlanetto and Robstad (2016) attribute the decrease in unemployment to immigrants arriving to Norway already with a job offer.

FIGURE 2. Immigration shock, aggregates



Notes: Shock to immigration that increases population by one percent. Variables are in percent deviations from the steady state. Employment and net migration are p.p. deviations from the level of indigenous population. Unemployment rate, job finding probability and job filling probability are in p.p..

FIGURE 3. Immigration shock, per capita and fiscal variables



Notes: Shock to immigration that increases population by one percent. Variables are in percent deviations from the steady state.

## 5 Endogenous migration and country-specific shocks

The advantage of the model in this paper is that the migration decision is endogenous. Unlike in Kiguchi and Mountford (2017), where country-specific shocks do not affect migration, here *any* country-specific shock triggers migration flows.

To illustrate the effects of endogenous migration for the dynamics of responses to country-specific shocks, this paper considers a temporary reduction in labour taxes paid by households and a temporary reduction in labour taxes paid by firms, both in the home country (similarly to Jacquinet et al. (2018)). The reason for choosing labour taxes is that they are a policy instrument, an important source of government revenue (in particular in Ireland) and can in addition have significant effects on the labour supply (Kilponen et al., 2015).

In all cases, the tax rate is changed temporarily by one percentage point. Impulse responses of the model with migration are compared to the impulse responses of the otherwise identical model, but with migration flows shut down.<sup>26</sup>

### 5 A decrease in labour taxes paid by households

A decrease in labour taxes paid by households implies that the surplus that is created when a firm and a worker meet becomes larger, because government takes a smaller

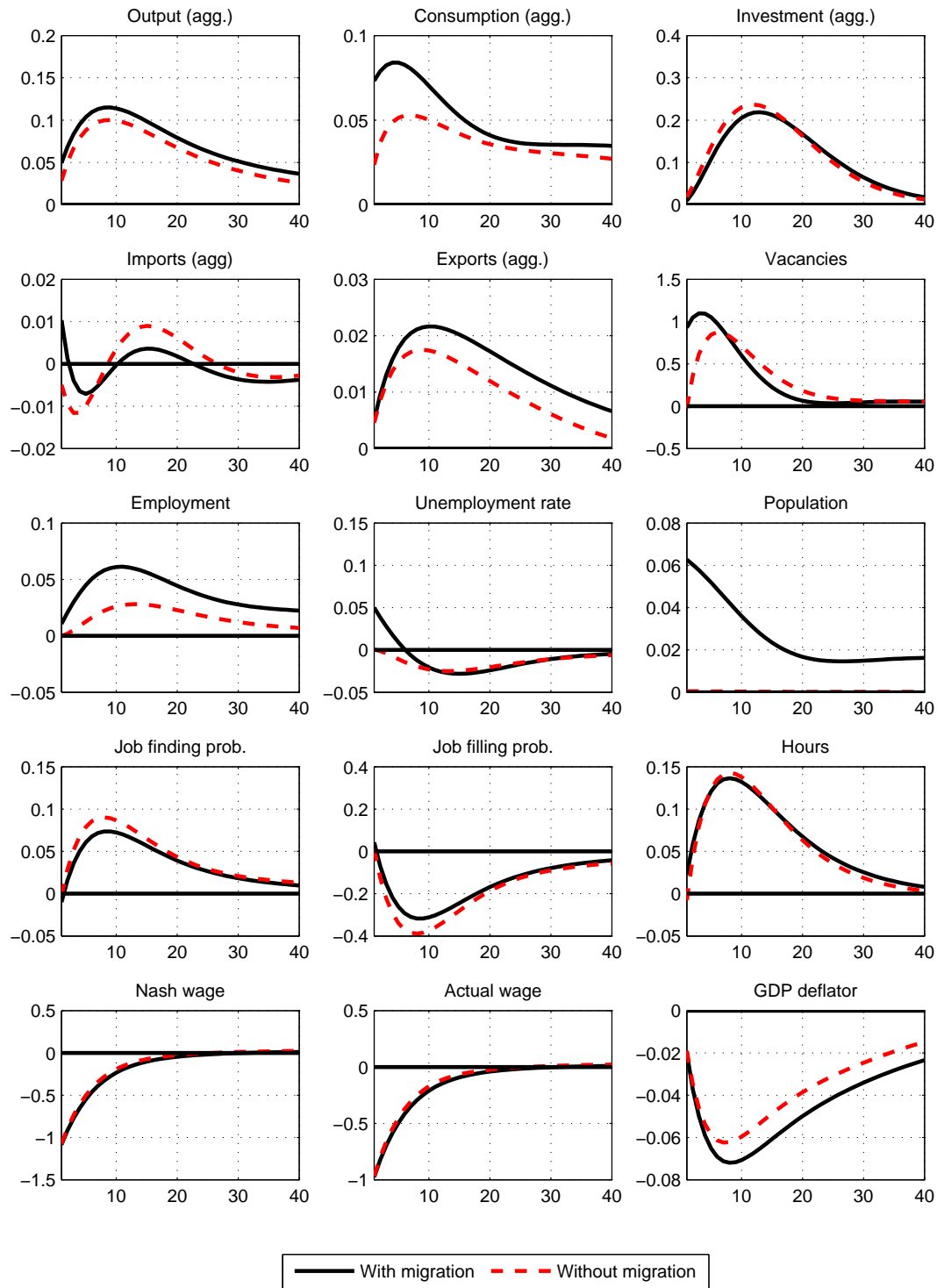
<sup>26</sup>This is achieved by setting  $\xi_L$  to a very large number (see equation 24), which switches off directed search while keeping the rest of the model unchanged.

share of the surplus. The share given up by the government accrues to households, but in the bargaining process, households have to cede some of this surplus to firms. They do so by agreeing on a lower wage (the take-home wage is still larger due to lower taxes). Lower wage costs cause higher profits, which induces firms to post more vacancies. Without migration (red dashed lines in Figures 4 and 5) employment increases and unemployment decreases. The decrease in unemployment increases tightness on the labour market, as there are more vacancies per unemployed person and the probability that firms fill the vacancies decreases. The gradual increase in employment and hours worked leads to an increase in output, while demand increases due to higher employment, higher after-tax income and the need to supplement an increase in employment with the increase in investment to maintain the capital-labour ratio. Exports increase because lower wages cause a drop in prices, which improves competitiveness. Imports do not move much despite domestic demand increase because demand shifts from foreign goods to relatively cheaper domestic goods.

The transmission mechanism with migration (full black line) is similar, except for the amplification that comes through the labour market. On impact, there is a temporary increase in unemployment caused by the arrival of immigrants. This has two effects. First, the job filling probability for firms increases on impact despite the stronger increase in vacancies, and then falls by less than in the case with no migration. A higher number of vacancies and a higher number of unemployed compared to the no-migration case imply that labour market is less congested (lower change of job finding and job filling probabilities) and that hiring is faster. The result is a much stronger increase in employment than in the no-migration case and a very quick reduction in unemployment. Unemployment rate decreases already after five periods, even though immigration is very persistent. Wage decrease is slightly larger than without immigration. In per-capita terms, all variables increase by less (or decrease by more) when there is immigration, but only by a very small amount.

Fiscal variables do not differ materially between the two cases, except the aggregate unemployment benefits paid, which are larger in the case of migration due to the initial increase in unemployment. This does not play an important role in the net tax revenues and quickly dissipates. The effects of higher employment on the tax base in the case of migration is neutralised by somewhat lower wages and somewhat lower hours worked compared to the no-migration case.

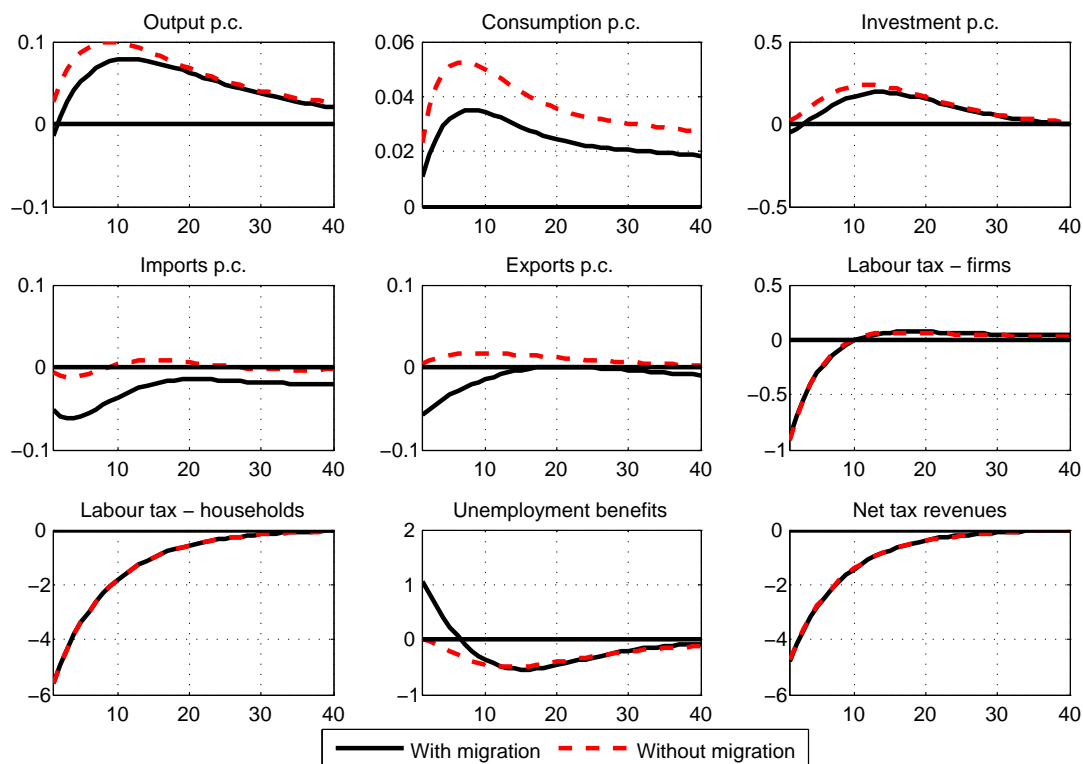
FIGURE 4. Reduction in labour taxes for households, with and without migration, aggregates



Notes: Reduction in labour taxes for households by 1 p.p. Variables are in percent deviations from the steady state. Employment and net migration are p.p. deviations from the level of indigenous population. Unemployment rate, job finding probability and job filling probability are in p.p..



FIGURE 5. Reduction in labour taxes for households, with and without migration, per capita and fiscal variables



Notes: Reduction in labour taxes for households by 1 p.p. Variables are in percent deviations from the steady state.

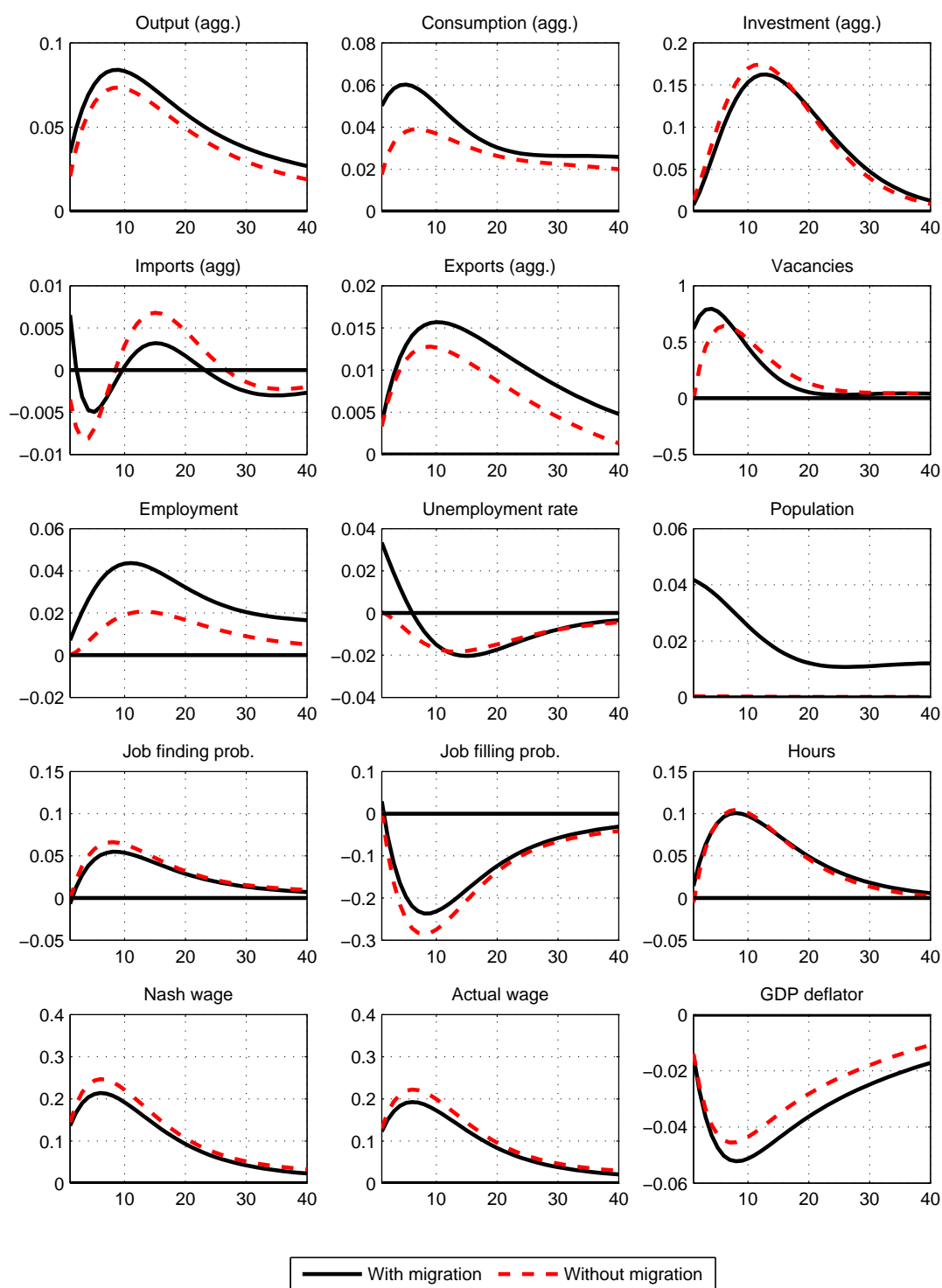
## 5 A decrease in labour taxes paid by firms

The effects of a decrease in labour taxes paid by firms on the home economy are shown in Figures 6 and 7. When labour taxes paid by firms are reduced, firms cede part of their gain during the bargaining process to households in the form of higher wages (but firms still gain in after-tax terms). When there is no migration (red dashed lines in Figures 6 and 7), firms post more vacancies due to lower after-tax labour costs, which increases employment and reduces unemployment. Output, investment, consumption and exports increase, similarly as when labour taxes for households are lower. The labour market becomes tighter and wages increase, which dampens some of the decrease in prices.

With migration (full black lines in Figures 6 and 7), higher wages in the home economy attract immigration. This initially increases the unemployment rate, but it also reduces the tightness on the labour market, as labour supply has increased. As a result, negotiated wages increase by less than in the case with no migration, which improves firm profitability and results in even more vacancies. Employment increases by more than when there is no migration and quickly absorbs the initial increase in unemployment. Because high immigration is contemporary with a high number of vacancies, this works against the congestion on the labour market (job finding and job filling probabilities change less). Lower labour costs improve competitiveness and exports increase.

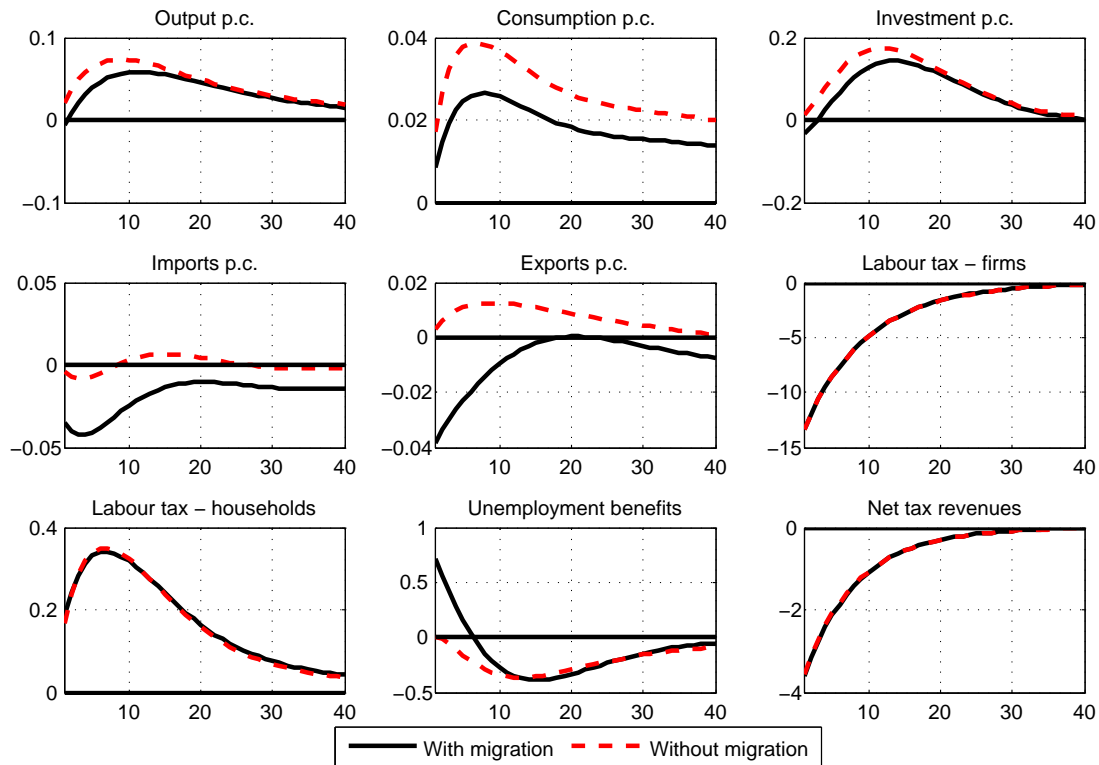
Similarly as when labour taxes for households are lowered, per-capita variables tend to be somewhat lower when there is migration (see Figure 7). There is no significant difference in the net tax revenues between the case with migration and the case without, as the initial increase in unemployment is short-lived and relatively small. The gains to the labour tax base from higher employment when there is immigration are mostly offset by somewhat lower wages and hours worked.

FIGURE 6. Reduction in labour taxes for firms, with and without migration, aggregates



Notes: Reduction in labour taxes for firms by 1 p.p. Variables are in percent deviations from the steady state. Employment and net migration are p.p. deviations from the level of indigenous population. Unemployment rate, job finding probability and job filling probability are in p.p..

FIGURE 7. Reduction in labour taxes for firms, with and without migration, per capita and fiscal variables



Notes: Reduction in labour taxes for firms by 1 p.p. Variables are in percent deviations from the steady state.

## 5 Relative country size, openness and the strength of migration flows

This section analyses how relative country size and its openness to migration affect migration flows. There are two reasons for that. First, countries that are small relative to the areas from where the potential pool of immigrants can come from have experienced larger migration flows over the cycle, as shown in section 2. Second, some countries have opened themselves to migration more than others, of which Ireland's opening to immigration from the Central and Eastern Europe is a typical example (Byrne and O'Brien, 2017).

Two cases are considered and to save space, all simulations consider only the reduction of labour taxes paid by firms. First, a country opens itself more to the same area. This is modelled as the reduction of  $\xi_L$  so that initial immigration after the tax reduction roughly doubles. Second, suppose the home country is large, but still open to migration. To investigate this, the relative country size is increased by reducing  $\theta$ , while keeping  $\xi_L$  the same, so that the country is as open to migration as it was before. The effects on the migration dynamics are shown in Figure 8.<sup>27</sup>

The black line in Figure 8 is the benchmark case and is identical to that in Figure 6. The dashed red line is a small economy, but much more open than the benchmark economy. The dotted blue line is a large economy, open to migration. When the home economy is large, then labour market adjustment to domestic shocks happens on both markets.

<sup>27</sup>Fiscal variables are omitted for the sake of space.

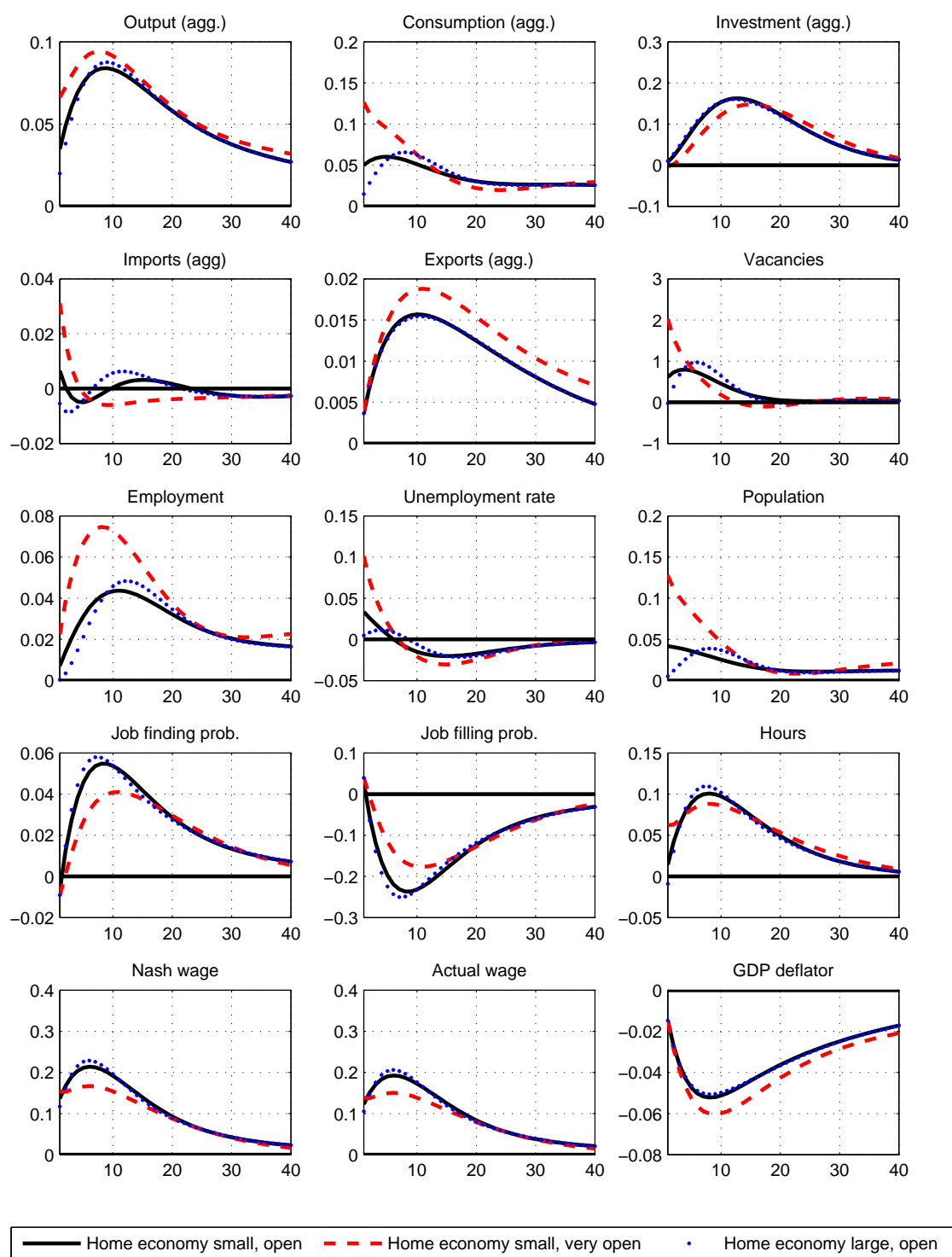
The differential between the value of being in the home labour market and the value of being in the foreign labour market, which causes migration, is smaller. Immigration to the home economy depletes the foreign labour market, resulting in an increase in wages abroad and slower immigration. This is seen in Figure 8 as a lower population increase in the home economy immediately following the shock. Slow immigration results in somewhat smaller and more protracted responses of domestic variables. In contrast, when the home economy is more open to migration (from the area of the same size), immigration has stronger effects on the home labour market and economic fluctuations. This happens because vacancies increase immediately on impact along with immigration (which happens with a delay when the home economy is large). A country-specific shock has significant labour supply effects through migration only for an economy that is small and open to migration towards a large area, as most of the adjustment will take place in the home labour market. This means that when a relatively small country opens its labour markets to a large area, this will lead to stronger fluctuations in labour supply than when it opens its markets to a smaller area.

These findings are interesting in view of the developments in Ireland described in Fitzgerald and Kearney (1999), who cover the period when Ireland's labour markets were open to the U.K., and stronger labour force fluctuations described by Byrne and O'Brien (2017), who cover the period when Ireland opened its labour market to the entire EU and did not restrict entry of workers from the Central and Eastern Europe. The latter period would be equivalent to Ireland becoming both more open to migration, and open to a larger area. The analysis above shows that becoming open to a larger area has relatively small effects, but the decision not to restrict immigration has stronger effects.<sup>28</sup>

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<sup>28</sup>The latter was likely amplified because the wage differential between Ireland and Central and Eastern Europe has also been substantially larger than the wage differential with Western Europe, resulting in stronger incentives to migrate.

FIGURE 8. Openness and country size



Notes: Reduction in labour taxes for firms by 1 p.p. Variables are in percent deviations from the steady state. Employment and net migration are p.p. deviations from the level of indigenous population. Unemployment rate, job finding probability and job filling probability are in p.p..

## 6 Conclusion

Economic migration is an important determinant of the labour supply at cyclical frequencies in many European countries, especially since the movement of labour has been free. In many European economies the change in net migration over the business cycle has exceeded one percent of the population and affected domestic labour market conditions.

The main finding of the paper is that migration amplifies cyclical fluctuations due to country-specific shocks. The reason for amplification is that migration affects labour force participation. After a positive shock to the home economy, the labour force increases due to immigration, which dampens the wage increase and the corresponding increase in firms' marginal costs. Firms become more profitable and post more vacancies, which in turn attracts new workers to the economy. Because there are simultaneously more vacancies and more searching workers, the matching process on the labour market is less congested, and employment and output increase more quickly and by more. Attenuated response of wages and stronger response of employment to domestic shocks result in flatter Phillips curve when migration is sizeable.

An exogenous increase in immigration leads to an increase in unemployment. This increase is temporary if wages adjust so that firms post more vacancies and unemployed find work. In this case, an increase in immigration has short-lived effects on unemployment. Moreover, additional net government spending associated with unemployment benefits for newcomers is quickly reversed due to higher tax collections. When wages do not adjust to immigration, unemployment persists and net government spending on unemployment benefits is not offset by the increase in tax revenues.

The impact of migration on the home labour market depends both on the relative size of the home economy and its openness to migration. When an economy is small and open to migration towards a large region, the size of its labour market is small relative to size of the pool of potential migrants. In such case, country-specific shocks can be significantly amplified by migration.

The finding that openness to migration magnifies fluctuations does not imply that larger fluctuations due to the presence of migration are sub-optimal. The investigation of this issue is left for future work.



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## A Calibration

Table 2 reports the main parameters used in the calibration of utility, labour market, taxation, and trade. Table 3 reports parameters used for the calibration of production, Great ratios, nominal and real rigidities. Unless otherwise stated, these parameters are based on Clancy and Merola (2016) and adjusted so that the calibration yields outcomes that are qualitatively the same as in Lozej et al. (2017), who use impulse-response matching to calibrate the dynamics of the model.

TABLE 2. Calibration of utility, labour, taxation, trade

| Parameter   | Value  | Target/Source                     |
|---|--------|-----------------------------------|
| <b>Utility function</b>                               |        |                                   |
| Inv. of int. el. of sub., $\sigma$                    | 2      | Clancy et al. (2016)              |
| Habit formation, $\kappa$                             | 0.4    |                                   |
| Weight of leisure, $\chi$                             | 0.6120 | $\bar{h} = 1$                     |
| Inv. of hours elast., $\eta$                          | 2      | Christoffel et al. (2009)         |
| <b>Matching function</b>                              |        |                                   |
| Elast. w.r.t. unempl., $\mu$                          | 0.5    | Petrongolo and Pissarides (2001)  |
| Mat. efficiency                                       | 0.3369 | $p^W = 0.16$ (Elsby et al., 2013) |
| <b>Other labour-related</b>                           |        |                                   |
| Breakup rate, $\delta_x$                              | 0.0101 | Unemp. rate 5%                    |
| Bargaining power, $\eta_B$                            | 0.5    | Hosios condition                  |
| Vacancy posting cost, $\psi$                          | 0.7917 | $p^F = 0.7$                       |
| Home-Foreign wage diff.                               | 0.15   | Net immigration 10%               |
| Replacement ratio, $rr$                               | 0.4    | Reduced est. by Min. of Fin.      |
| Weight on current wage, $\lambda_w$                   | 0.9    | -                                 |
| <b>Taxation</b>                                       |        |                                   |
| Consumption tax, $\tau^c$                             | 21.9%  | European Commission               |
| Labour tax - households, $\tau^{wh}$                  | 21.3%  | European Commission               |
| Labour tax - firms, $\tau^{wf}$                       | 7.4%   | European Commission               |
| Capital tax, $\tau^k$                                 | 8.6%   | European Commission               |
| Persist. of lab. tax - households, $\rho_{\tau^{wh}}$ | 0.9    |                                   |
| Persist. of lab. tax - firms, $\rho_{\tau^{wf}}$      | 0.9    |                                   |
| <b>Trade shares</b>                                   |        |                                   |
| Consumption imports, $\omega_C$                       | 0.3795 | Share in GDP                      |
| Investment imports, $\omega_I$                        | 0.5855 | Share in GDP                      |
| Imports of exports, $\alpha$                          | 0.5    | Clancy and Merola (2016)          |
| <b>Country size</b>                                   |        |                                   |
| Rel. size of Foreign, $\theta$                        | 100    | Size of EU pop. rel. to IE        |

TABLE 3. Calibration of production, Great ratios, pricing, adjustment costs

| Parameter                               | Value | Target/Source             |
|---|-------|---------------------------|
| <b>Great ratios</b>                     |       |                           |
| Capital depreciation                    | 0.025 | 10% annually              |
| Government spending                     | 0.203 | Government spending share |
| <b>Real rigidities</b>                  |       |                           |
| Inv. adj. costs, $\xi_I$                | 8     |                           |
| Export adj. costs, $\xi_X$              | 0     |                           |
| <b>Nominal rigidities</b>               |       |                           |
| Non-tradable price adj. cost, $\xi_N$   | 1700  |                           |
| Import price adj. cost, $\xi_M$         | 0     |                           |
| Export price adj. cost, $\xi_{Xp}$      | 5000  |                           |
| Indexation - nontradable, $\omega_{Pn}$ | 0.1   |                           |
| Indexation - imports, $\omega_{Pm}$     | 0.1   |                           |
| Indexation - exports, $\omega_{Px}$     | 0.1   |                           |
| Markup - nontradable, $\mu_N$           | 10%   |                           |
| Markup - imports, $\mu_M$               | 10%   |                           |
| Markup - exports, $\mu_X$               | 10%   |                           |
| <b>Production functions</b>             |       |                           |
| Labour share - nontradable, $\gamma_N$  | 0.58  | Investment share          |
| Labour share - tradable, $\gamma_X$     | 0.4   | Clancy and Merola (2016)  |

## B Main model equations

This section outlines the main changes made to the model equations compared to those of Clancy and Merola (2016). The main changes were the generalisation of the utility function to the CRRA form with habit formation. Final consumption and investment goods are now CES-aggregates of imports and home-produced goods, with the corresponding price indices. Taxes on consumption, income, and capital are added and the budget constraint of the government changes accordingly. Depreciation of foreign-owned sector capital is replaced by foreign investment, and a fraction of profits remaining after paying labour and purchasing investment goods is transferred abroad. Finally, a share of immigrant labour income is transferred abroad as remittances.

**Utility function.** Households maximise the following utility:

$$\max_{C_{t+j}, I_{t+j}, K_{t+j+1}} \sum_{j=0}^{\infty} \left( \frac{(C_{t+j} - \kappa C_{t+j-1})^{1-\sigma}}{(1-\kappa)^{-\sigma}(1-\sigma)} - \chi_N \frac{h_{t+j}^{1+\eta}}{1+\eta} \right) P_{op,t}, \quad (25)$$

subject to the budget constraint that now includes taxes, which results in the following first order conditions for consumption, bond holdings, and capital:

$$(1-\kappa)^\sigma (C_t - \kappa C_{t-1})^{-\sigma} = (1 + \tau_t^C) \lambda_t P_t, \quad (26)$$

$$\lambda_t = \beta R_t \lambda_{t+1}, \quad (27)$$

$$P_{K,t} = \beta \frac{\lambda_{t+1}}{\lambda_t} \left( (1 - \tau_{t+1}^K) R_{K,t+1} + (1 - \delta) P_{K,t+1} \right), \quad (28)$$

where  $C_t$  is consumption per capita,  $P_t$  the price of consumption,  $\lambda$  the Lagrange multiplier on the budget constraint,  $R_t$  the nominal interest rate,  $P_{K,t}$  price of capital goods,  $R_{K,t}$  is return on capital, and  $P_{op,t}$  is population.<sup>29</sup>  $\tau_t^C$  and  $\tau_t^K$  are tax rates on consumption and capital income, respectively.  $\kappa$  determines habit formation,  $\sigma$  is the inverse of the intertemporal elasticity of substitution for consumption,  $\beta$  is the household's discount factor and  $\delta$  is the depreciation rate.

**Demand for consumption and investment imports.** In Clancy and Merola (2016) production function of the tradable sector is  $Y_t = A_t K_{X,t-1}^{1-\gamma_X} N_{X,t}^{\gamma_X}$ , where  $K_X$  is aggregate foreign-owned capital and is constant and exogenous. This assumption is relaxed here by assuming that foreign multinationals replenish depreciated capital by purchasing investment goods in home and abroad, which increases demand for investment goods by  $\delta K_{X,t-1}$ .<sup>30</sup> Investment goods can be produced either at home or abroad. Total demand for investment goods,  $P_{op,t} I_t + \delta K_{X,t-1}$  is split on imported and home-produced goods by assuming that final investment goods are assembled from intermediate goods using a CES-aggregator. Demand functions for aggregate investment imports,  $P_{op,t} I_{M,t}$  and for home-produced investment goods,  $P_{op,t} I_{N,t}$ , are:

$$P_{op,t} I_{M,t} = \omega_I \left( \frac{P_{M,t}}{P_{I,t}} \right)^{-\mu_I} (P_{op,t} I_t + \delta K_{X,t-1}), \quad (29)$$

$$P_{op,t} I_{N,t} = (1 - \omega_I) \left( \frac{P_{N,t}}{P_{I,t}} \right)^{-\mu_I} (P_{op,t} I_t + \delta K_{X,t-1}), \quad (30)$$

where  $P_{M,t}$  is the price of imports,  $P_{N,t}$  the price of non-tradable goods, and  $P_{I,t}$  the price of investment goods. Parameter  $\mu_I$  is the demand elasticity for investment goods and  $\omega_I$  is the quasi-share of investment imports in total investment goods. The price of investment goods is:

$$P_{I,t} = \left( (1 - \omega_I) P_{N,t}^{1-\mu_I} + \omega_I P_{M,t}^{1-\mu_I} \right)^{\frac{1}{1-\mu_I}}. \quad (31)$$

The final consumption good is also assumed to consist of CES-aggregated imported and home-produced intermediate goods. The equations are the same as for investment (except for investment demand from foreign multinationals), so I do not reproduce them here.

**Government budget.** Government budget accounts for unemployment benefits and all taxes in addition to government consumption spending (determined as a fraction of steady-state aggregate GDP,  $P_t G_t = \bar{g} \bar{Y}$ ). Lump-sum taxes,  $T_t$ , adjust to restore government balance.

$$P_{N,t} G_t + b P_t U_t = (\tau_t^{wh} + \tau_t^{wf}) P_t h_t w_t n_t + \tau_t^C P_t C_t + \tau_t^K R_{K,t} K_{t-1} + T_t \quad (32)$$

<sup>29</sup>Note that the price of capital can be expressed as  $P_{K,t} = q_t / \lambda_t$ , where  $q_t$  is the Lagrange multiplier on the law of motion for capital (Tobin's  $q$ ).

<sup>30</sup>The reason for relaxing this constraint is that this facilitates the calibration of investment share in GDP.

**Foreign debt.** The equation for foreign debt takes into account that a fraction  $\phi_\pi$  of profits earned by foreign multinationals, after paying for investment to replenish depreciated capital and net of taxes, is transferred abroad. Similarly, a fraction  $\phi_R$  of after-tax earnings of employed immigrants are transferred abroad as remittances. These assumptions result in the following equation for the law of motion of aggregate foreign debt,  $B_t$ , in nominal terms:

$$B_t = B_{t-1}R_{t-1} - TB_t + \phi_\pi \left( (P_{X,t} - \alpha P_{M,t} - W_{X,t}n_{X,t} - \tau_t^K R_{K,t}K_{X,t-1} - \delta K_{X,t-1}P_{K,t}) \right) + \phi_R \left( (1 - \tau_t^{wh}) P_t w_t h_t n_{F,t} \right), \quad (33)$$

where  $TB_t$  is the trade balance,  $P_{X,t}$  is the price of exports,  $P_{M,t}$  is the price of imports,  $W_{X,t}$  is the nominal wage in the export sector,  $n_{X,t}$  are the effective labour services in the export sector, and  $n_{F,t}$  is the number of foreign employed in Home.



